

**FABRICATION APPARATUS FOR WAFER BAKING PLATE**

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**PRIORITY**

This application claims priority under 35 U.S.C. § 119 to an application entitled “Cooling Apparatus for Wafer Baking Plate” filed in the Korean Intellectual Property Office on June 4, 2003 and assigned Serial No. 2003-36021, 10 the contents of which are incorporated herein by reference.

**BACKGROUND OF THE INVENTION**

1. Field of the Invention

15 The present invention relates generally to a wafer fabricating apparatus, and in particular, to an apparatus for cooling a baking plate on which a photoresist layer deposited on a wafer is baked.

2. Description of the Related Art

20 In general, semiconductor device fabrication involves photolithography. For photolithography, a photoresist layer is formed by depositing a photoresist on a wafer, which is then patterned by exposing the photoresist layer to a predetermined light source such as a laser. The wafer is heated and baked repeatedly during this process.

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Heating is performed in four steps in the process of semiconductor device fabrication: (1) pre-baking for removing organic materials or foreign materials from a wafer before formation of a photoresist layer; (2) soft baking for drying the photoresist layer deposited on the wafer for fixing the layer to the 30 wafer; (3) post-exposure baking for exposing the photoresist layer to a light

source and then heating the photoresist layer; and (4) hard baking for tightly attaching a pattern resulting from development of the exposed photoresist layer onto the wafer. The wafer heating is carried out at various temperatures according to the type of photoresist and may be varied during the heating steps.

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A wafer baking plate for setting various heating temperatures is disclosed in Japanese Patent Application No. 1999-205079 filed on July 19, 1999. The wafer baking plate has a path for running a cooling medium therein to cool the baking plate.

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However, conventional fabrication apparatuses for the wafer baking plate are slow in transferring heat and typically take a long time to achieve a uniform temperature distribution for the wafer baking plate. Even if the baking plate is cooled down rapidly, uniform temperature distribution takes a long time, thereby 15 reducing wafer product yield.

## SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a fabrication 20 apparatus for a wafer baking plate, which shortens the time required to cool down the wafer baking plate and rapidly stabilizes temperature distribution.

The above object is achieved by a fabrication apparatus for a wafer baking plate having a support plate for supporting a wafer, a heater under the 25 support plate, and a heat transfer plate interposed between the support plate and the heater, for transferring heat. In the fabrication apparatus, a hollow bore is formed in the heat transfer plate of the wafer baking plate and partially filled with a liquid working fluid. A cooling pipe is laid in the heat transfer plate, for circulating a cooling medium.

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**BRIEF DESCRIPTION OF THE DRAWINGS**

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description,

5 when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of a wafer baking plate according to a preferred embodiment of the present invention;

FIG. 2 is a cross-sectional view of the wafer baking plate, taken along line A-A' illustrated in FIG. 1;

10 FIG. 3 is a partial enlarged sectional view of the wafer baking plate illustrated in FIG. 2;

FIG. 4 is a cross-sectional view of the wafer baking plate, taken along line B-B' illustrated in FIG. 2;

15 FIG. 5 is a cross-sectional view of an embodiment of the wafer baking plate illustrated in FIG. 2 with a cooling pipe according to the present invention;

FIG. 6 is a cross-sectional view of another embodiment of the wafer baking plate illustrated in FIG. 2 with a cooling pipe according to the present invention;

20 FIG. 7 is a cross-sectional view of a third embodiment of the wafer baking plate illustrated in FIG. 2 with a cooling pipe according to the present invention;

FIG. 8 is a cross-sectional view of a fourth embodiment of the wafer baking plate illustrated in FIG. 2 with a cooling pipe according to the present invention;

25 FIGs. 9A, 9B and 9C illustrate cross-sectional shapes of a cooling pipe for the wafer backing plate illustrated in FIG. 2;

FIG. 10 depicts a heating operation for the wafer baking plate illustrated in FIG. 2;

30 FIG. 11 depicts a cooling operation for the wafer baking plate illustrated in FIG. 2;

FIG. 12 illustrates cooling curves of the wafer baking plate illustrated in FIG. 1; and

FIG. 13 illustrates a cooling curve of a wafer baking plate according to a conventional natural cooling method.

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## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described herein below with reference to the accompanying drawings. In the following description, 10 well-known functions or constructions are not described in detail since they would obscure the invention in unnecessary detail.

FIG. 1 is a perspective view of a wafer baking plate 100 according to a preferred embodiment of the present invention, FIG. 2 is a cross-sectional view 15 of the wafer baking plate 100, taken along line A-A' illustrated in FIG. 1, FIG. 3 is a partial enlarged cross-sectional view of the wafer backing plate 100, and FIG. 4 is a cross-sectional view of the wafer baking plate 100, taken along line B-B' illustrated in FIG. 2. As illustrated in FIGs. 1 to 4, the wafer baking plate 100 is comprised of a support plate 101, a heater 102 under the support plate 101, and a 20 heat transfer plate 103 between the support plate 101 and the heater 102. The wafer baking plate 100 includes a fabrication apparatus having a cooling pipe 105 laid inside the heat transfer plate 103.

In the wafer baking plate 100, a mounting surface 111 is defined on the 25 support plate 101 and guide protrusions 113 are formed around the mounting surface 111, for preventing movement of a wafer. The heat transfer plate 103 can be formed integrally with the support plate 101. The heat transfer plate 103 is a medium that transfers heat from the heater 102 to the support plate 101 and has a hollow bore or track 131 partially filled with a liquid working fluid 139 therein. 30 The hollow bore 131 can be segmented by a plurality of separators 133 inside the

heat transfer plate 103. As illustrated in FIG. 4, the separators 133 are concentrically arranged within the heat transfer plate 103.

The cooling pipe 105 introduces a cooling medium, circulates it around 5 the heat transfer plate 103, and then discharges it outside the plate 100. The cooling pipe 105 is laid spirally along the hollow bore 131 of the heat transfer plate 103 as illustrated in FIG. 4. The cooling pipe 105 has an inlet and an outlet close to each other. Preferably cooling medium in and out paths are parallel in order to offset the temperature difference between the injected cooling medium 10 and the discharged cooling medium and thus maintain a uniform temperature distribution across the wafer baking plate 100. While a single pipeline is used as the cooling pipe 105, a plurality of pipelines can be installed to thereby circulate more cooling medium at a given time and shorten cooling time.

15 As illustrated in FIGs. 5 and 6, the cooling pipe 105 can be laid simply in the hollow bore 131 (Fig. 5) or in a groove 137 (Fig. 6) formed in the bottom of the hollow bore 131. The cooling pipe 105 can also be buried under the hollow bore 131 as illustrated in FIG. 7, or a plurality of cooling pipes 105 can be installed, such as the two shown in Fig. 8, with one in the hollow bore 131 and 20 the other buried under the hollow bore 131.

Referring to FIGs. 9A, 9B and 9C, the cross-section of the cooling pipe 105 can be circular, oval or polygonal. To improve heat transfer efficiency, cooling fins or wrinkles may be formed on the inner and outer circumferential 25 surfaces of the cooling pipe 105.

Referring to FIG. 10, when the heater 102 emits heat, as indicated by reference character B, the heat is transferred to the heat transfer plate 103 and the working fluid 139 is vaporized as indicated by reference character C. The 30 vaporized working fluid transfers heat as indicated by reference character D,

returns to a liquid state, and then receives heat from the heater 102 again. The phase transition of the working fluid 139 occurs in a closed cycle within the hollow bore 131 and the heat from the heater 102 is effectively transferred to the support plate 101 via the vaporized working fluid 139. Since the heat transfer is 5 carried out through the phase transition of the working fluid 139, temperature distribution is uniform across the support plate 101.

Preferably, the interior of the cooling pipe 105 is vacuumed or filled with air during the heating. If a liquid such as a cooling medium is filled in the cooling 10 pipe 105, the heat from the heater 102 is not effectively transferred to the support plate 101, and only heats the liquid in the cooling pipe 105.

Cooling of the baking plate 100 will be described with reference to FIG. 11. To rapidly cool the baking plate 100, the cooling medium is circulated 15 through the cooling pipe 105. For the cooling medium, water can be used. Along with the circulation of the cooling medium, the heat from the support plate 101 is absorbed by the cooling pipe 105 as indicated by reference character D', and the heat of the heat transfer plate 103 and the heater 102 is absorbed by the cooling pipe 105 as indicated by reference characters C' and B'. As a result, heat around 20 the cooling pipe 105 is absorbed by the cooling medium of the cooling pipe 105. The cooling medium is continuously injected into the cooling pipe 105 and circulated around the heat transfer plate 103, thus cooling the baking plate 100.

Similarly, the heat of the baking plate 100 is absorbed by the cooling 25 pipe 105 through the working fluid 139, resulting in a uniform temperature distribution across the support plate 101 and remarkably reducing cooling time.

FIG. 12 shows a graph 109 illustrating cooling curves when the cooling apparatus for the baking plate 100, illustrated in FIG. 4, operates. The graph 109 30 illustrates temperature change while the average temperature of the baking plate

100 falls from 150°C to 100°C in the case where a cooling medium is circulated at 18°C at 1.5l/min. Reference numeral ① denotes a curve showing the change of the average temperature of the baking plate 100 in time and reference numeral ② denotes a curve showing the change of the maximum temperature deviation of 5 the baking plate 100 in time.

Referring to FIG. 12, it is noted from curves ① and ② that the average temperature of the baking plate 100 drops to 100°C 15 seconds after the fabrication apparatus starts to operate in the present invention. Then the cooling 10 water injection is discontinued and the cooling pipe is filled with air. Thirty seconds later, the temperature deviation of the baking plate 100 is reduced markedly, and 50 seconds later, its temperature distribution is stabilized.

FIG. 13 shows a graph 209 illustrating temperature change in a wafer 15 baking plate according to conventional natural cooling method. While the natural cooling leads to a relatively uniform temperature distribution on the wafer baking plate during cooling, 45 minutes is taken to cool the wafer baking plate from 150°C to 100°C, thereby significantly decreasing product yield, as illustrated in FIG. 13. On the contrary, the fabrication apparatus of the present invention 20 rapidly cools the baking plate, achieving a uniform temperature distribution only in 50 seconds.

In accordance with the present invention as described above, the fabrication apparatus for a wafer baking plate has a cooling pipe laid in a heat 25 transfer plate partially filled with a liquid working fluid, for rapid cooling of the wafer baking plate. Since the heating and cooling of the baking plate is carried out via the working fluid, the temperature is uniform across the baking plate.

Furthermore, the maintenance of the uniform temperature distribution during heating or cooling the wafer baking plate increases product yield.

While the invention has been shown and described with reference to a 5 certain preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.